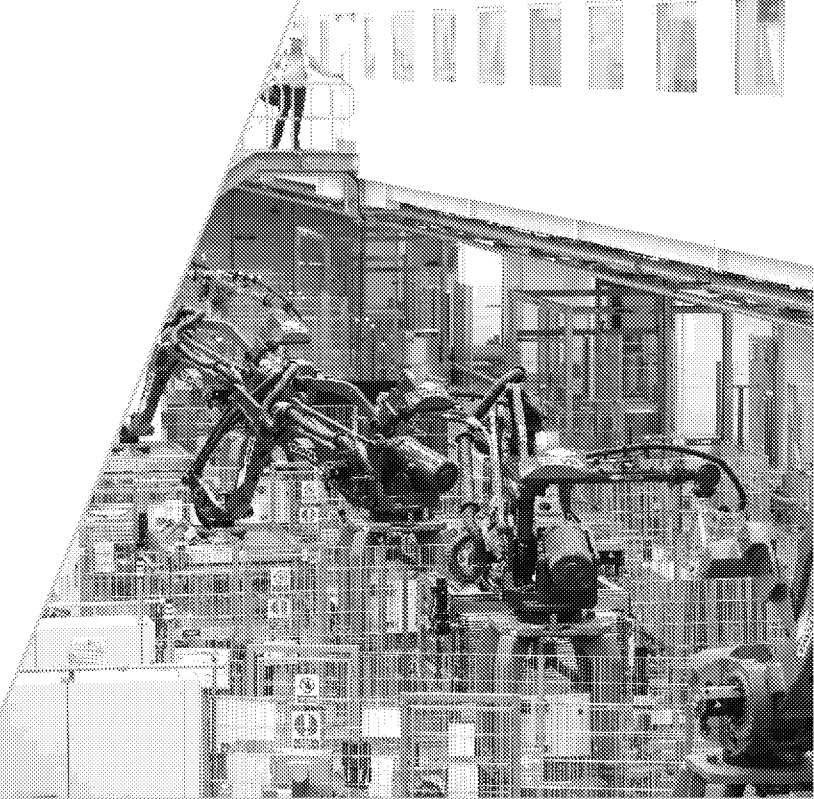


Advanced Materials Product Outline

Composites, 3D printing, new materials, and
circular economy

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December 17, 2019



BloombergNEF

BNEF's coverage

Pipeline and current research library

Advanced Materials – Research coverage areas

Circular economy and sustainable materials

The core strategies underpinning product sustainability. Industry must increase its use of low carbon materials and address material supply chains in order to decarbonize.

- Scenarios for material demand and recycling
- Company strategy and goals for bioplastics, circular economy
- Recycling technology primers and capacity database
- Government policy and targets for recycling, extended producer responsibility schemes, landfill
- Circular economy case studies
- Bioplastics supply, demand, and cost
- Bioplastics technology primers

Theme page: **Materials for sustainability and the circular economy**
([web](#) | [terminal](#))

3D printing and advanced manufacturing

3D printing represents a shift in manufacturing towards greater automation and decentralization. We track adoption of the technologies enabling the change.

- 3D printer machine and materials costs
- Startup and industrial company strategy and product offerings
- Industrial applications and capabilities
- Economic crossover points and competition with incumbents
- Investment, partnerships and news
- Technology primers and case studies
- Impacts of 3D printing on other sectors: logistics, transport, manufacturing, materials and chemicals, oil and gas.

Theme page: **Next generation manufacturing**
([web](#) | [terminal](#))

Composites

A key advanced material for the transport and wind supply chains. We track supply, demand, prices, and company strategy.

- Carbon fiber manufacturer company strategy and profiles
- Price surveys and cost drivers
- Supply and demand dynamics
- Recycling and sustainability
- Investment, partnerships, and industry news
- Carbon fiber manufacturing capacity database
- Technology primers
- Lightweighting and industrial applications

Theme page: **Composite materials for energy and transport**
([web](#) | [terminal](#))

2020 research pipeline

Composites

Recycling technologies for composite materials

Demand from the wind industry

Demand from the aerospace industry

Advanced manufacturing technologies for composites

Supply chains and competitive analysis in the carbon fiber supply chain

Composite materials outlook

Advanced manufacturing

3D printing materials company profiles

3D printing in the auto industry

Startups and industrial 3D printing suppliers

Competitive analysis for 3D printing suppliers

Part teardown: 3D printing versus traditional manufacturing

Reliability and tolerances in 3D printing

Circular economy

Circular economy modelling: PE, PP, copper, steel, glass, pulp and paper

Packaging tradeoffs

Recycling supply chains

Costs and penalties of disposal options

Recycled material pricing analysis

Company exposure to the circular economy

Industrial composting and bioplastics

State of recycling in the U.S.

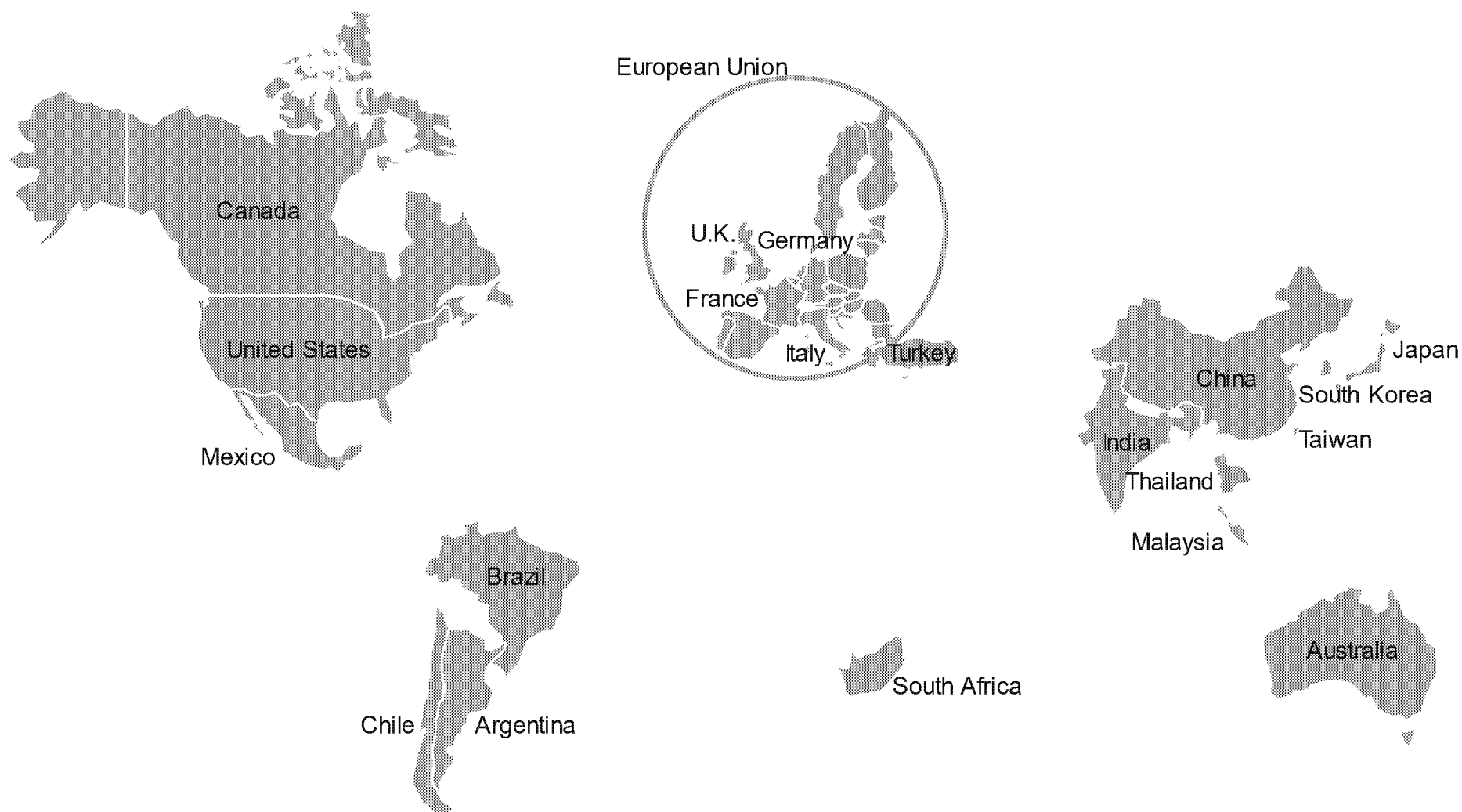
China's progress on the circular economy

Consumer sentiment on alternative packaging and the circular economy

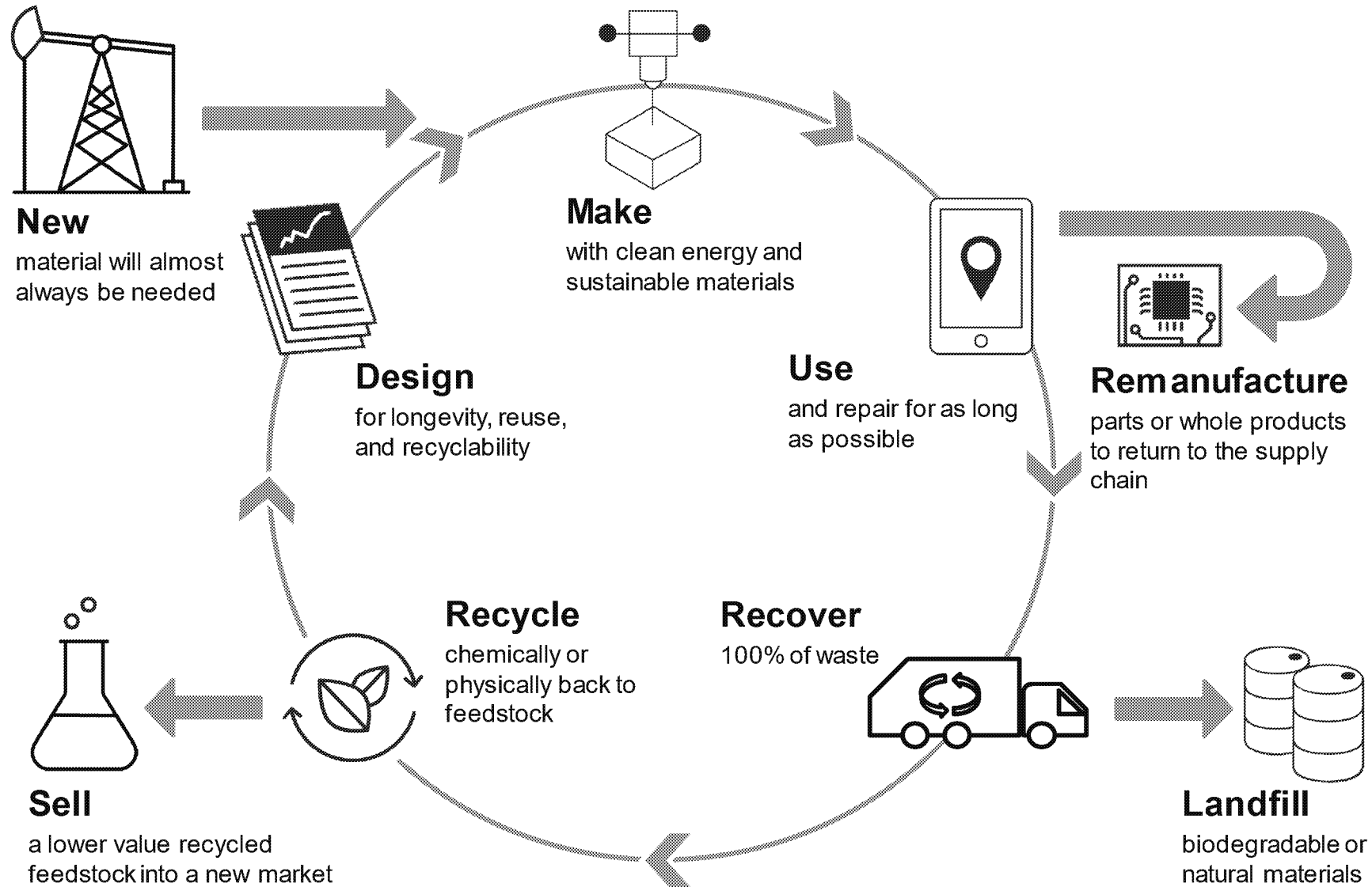
Sustainability and the Circular Economy

Recycling, bioplastics, and policy

Countries are turning to policy to create a circular economy



Companies are adopting circular economy strategies

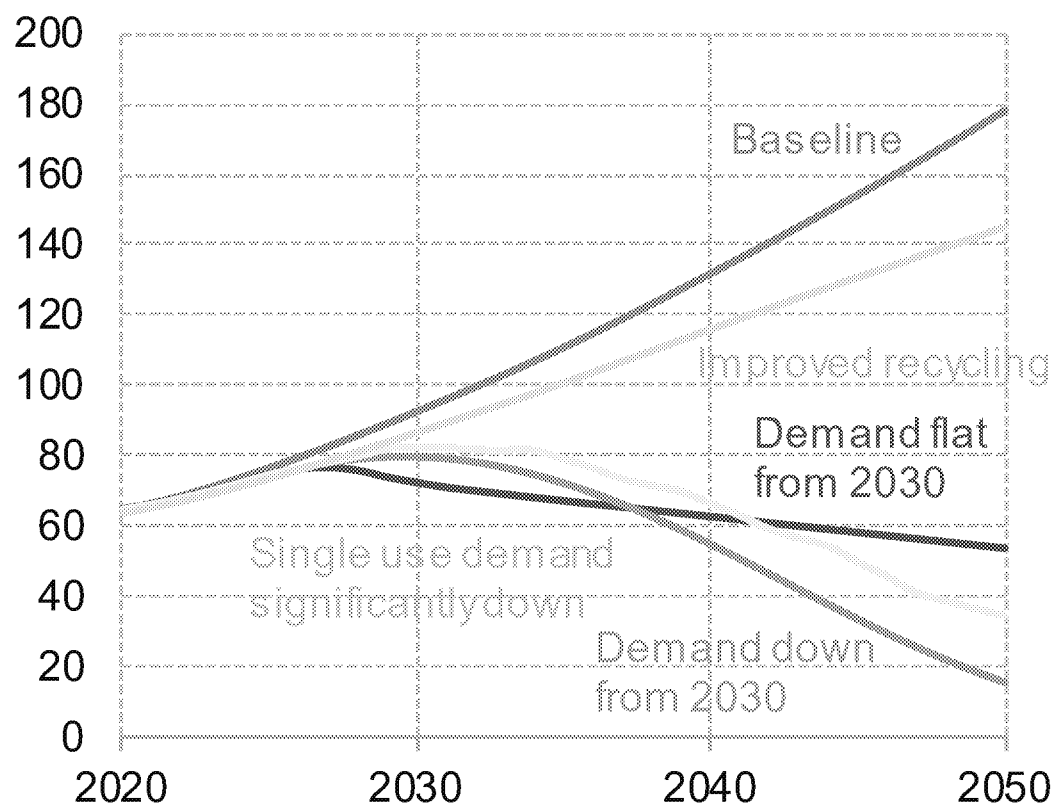


Source: BloombergNEF.

Both demand and recycling have a big impact on emissions

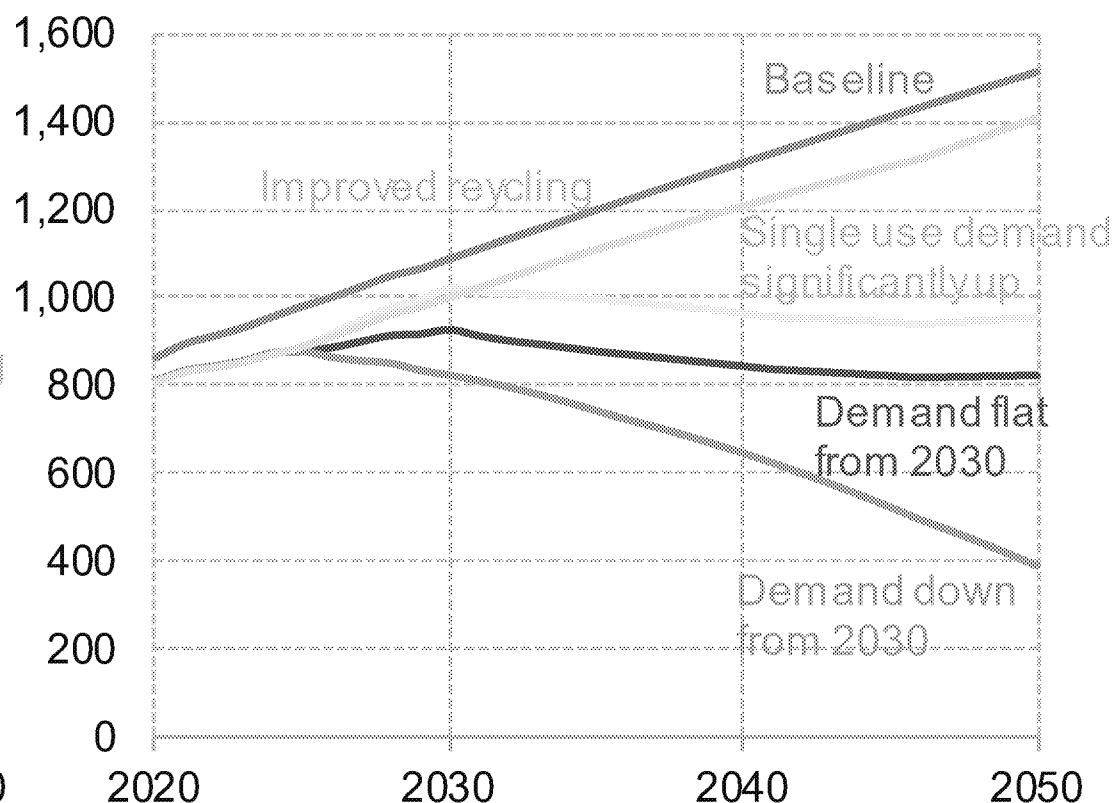
PET plastic

CO2 equivalent emissions (Mt per year)



Aluminum

CO2 equivalent emissions (Mt per year)

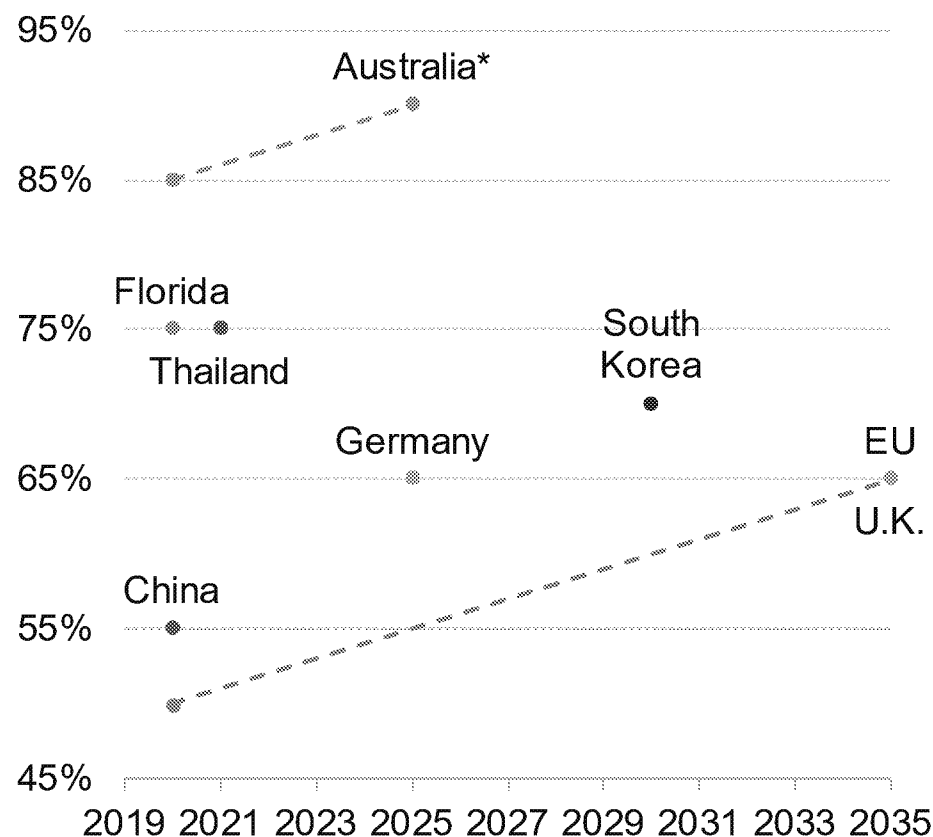


Source: BloombergNEF.

Countries have ambitious recycling targets, backed by policy

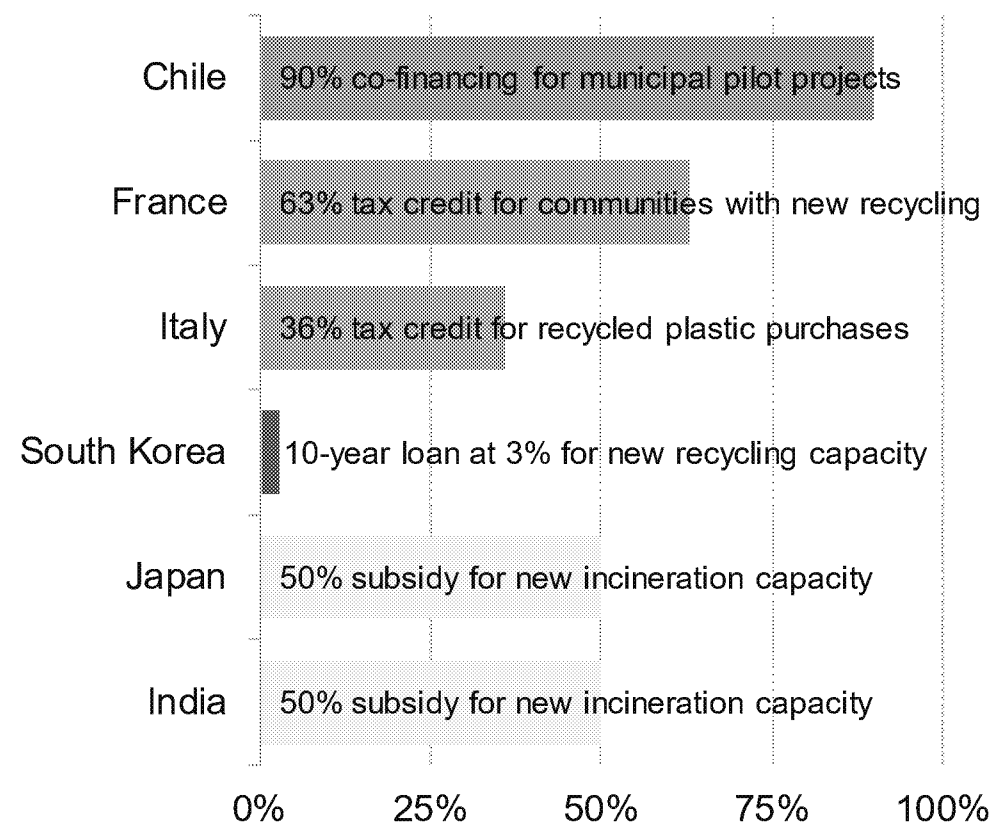
Municipal solid waste (MSW) recycling targets

% of MSW recycled



Source: BloombergNEF Circular Economy Policy Database ([web](#) | [terminal](#)) Note: Australia is for Capital Territory

Financial incentives for recycling and incineration

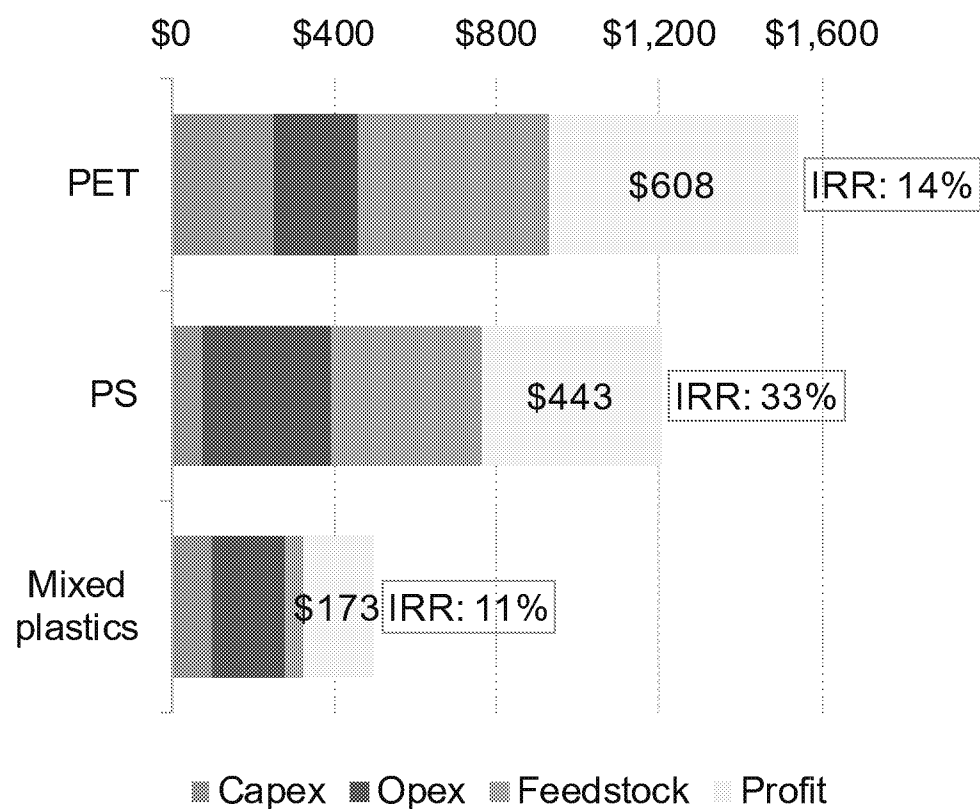


Source: BloombergNEF Circular Economy Policy Database ([web](#) | [terminal](#)) Note: Japan and India's subsidies are for incineration with energy recovery

Chemical recycling is profitable and growing

Economics of chemical recycling

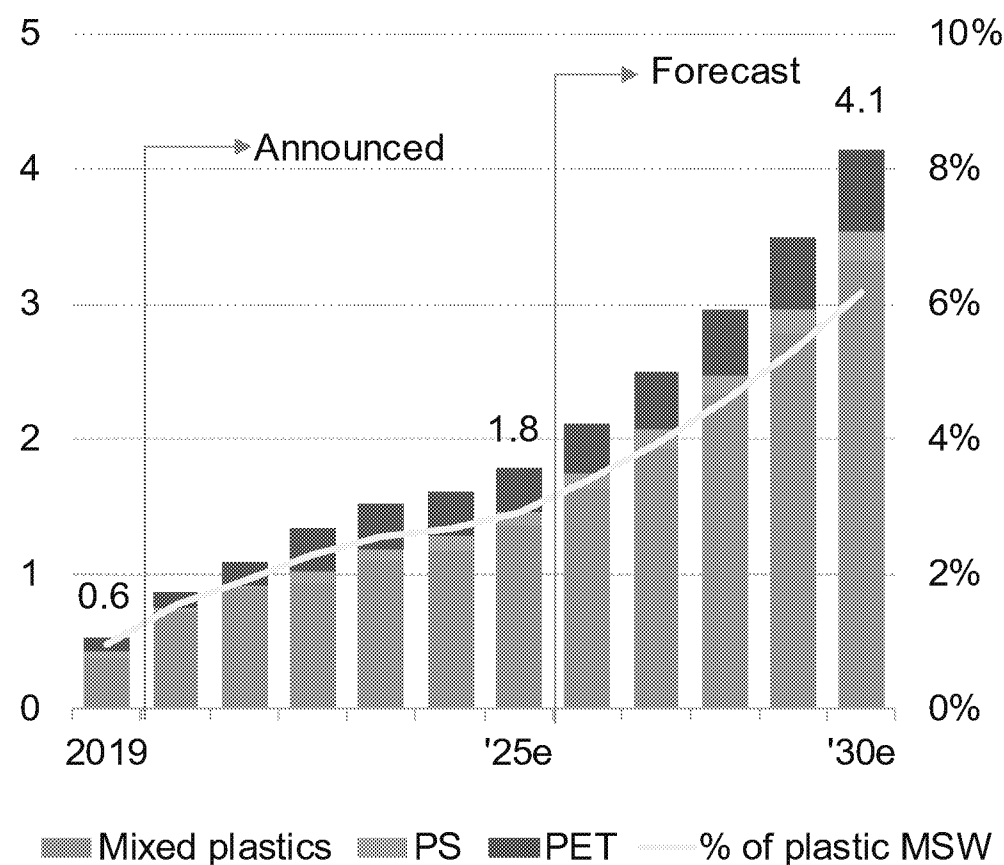
\$ per metric ton of recycled output



Source: BloombergNEF

Chemical recycling cumulative capacity outlook

Million metric tons




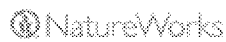






Source: BloombergNEF

Bioplastics

Supply, demand, and pricing

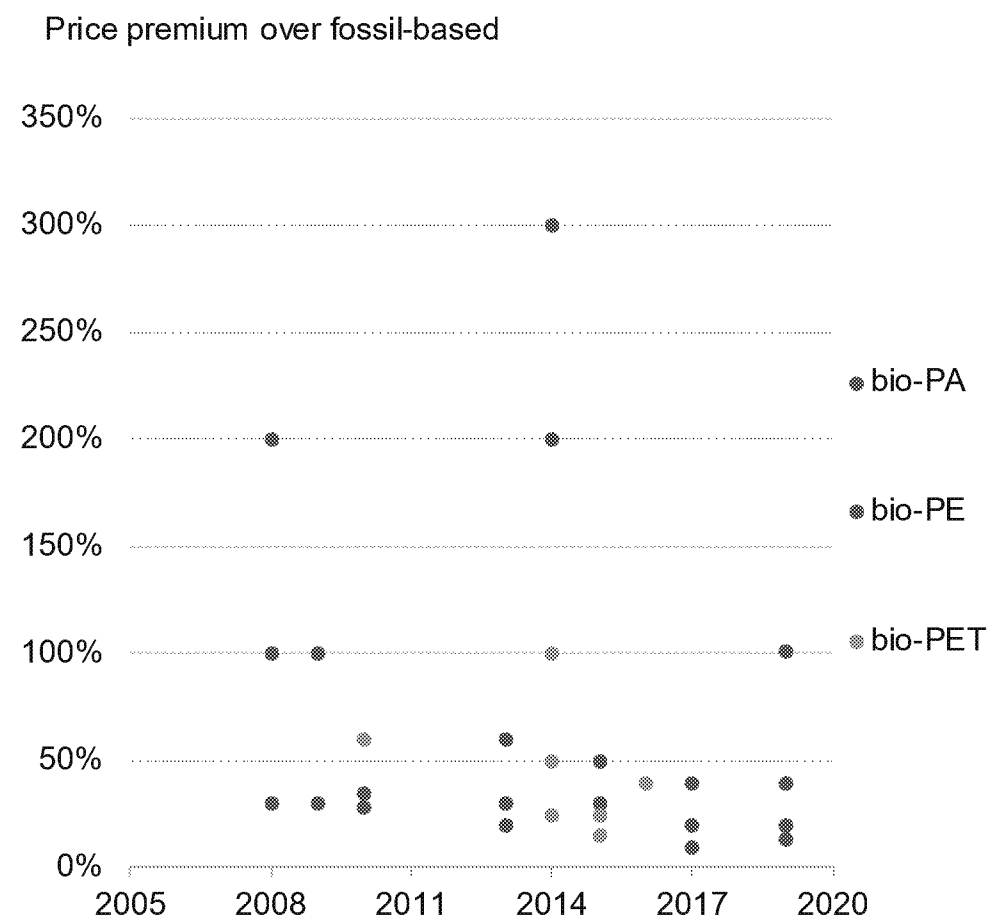
There's a bioplastic for every application

	Bio-based	Bio-degradable	Market share	Key markets	Substitutes	Key producers
Drop-ins						
Bio-PE (bio-polyethylene)	✓	✗	9%	Packaging Consumer goods	PE	Braskem 
Bio-PET* (bio-polyethylene terephthalate)	✓	✗	42%	Rigid packaging Automotive	PET	INDORAMA 
Bio-PA (bio-polyamides)	✓	✗	4%	Automotive Construction	PA	ARKEMA 
Substitutes						
PLA (polylactic acid)	✓	✓	11%	Packaging Textiles	PS, PP, ABS	NatureWorks 
PHA (polyhydroxyalkanoates)	✓	✓	3%	Packaging Automotive	PE, PP, PVC	NEWLIGHT 
Bio-PBS* (polybutylene succinate)	✓	✓	15%†	Flexible packaging Consumer goods	PE, PP	MITSUBISHI CHEMICAL 
PBAT (polybutylene adipate terephthalate)	✗	✓		Packaging Agriculture	PE, PS	BASF  We create chemistry
Starch-based (thermoplastic starch blends)	✓	✓	8%	Flexible packaging Consumer goods	Depends on blend	NOVAMONT 

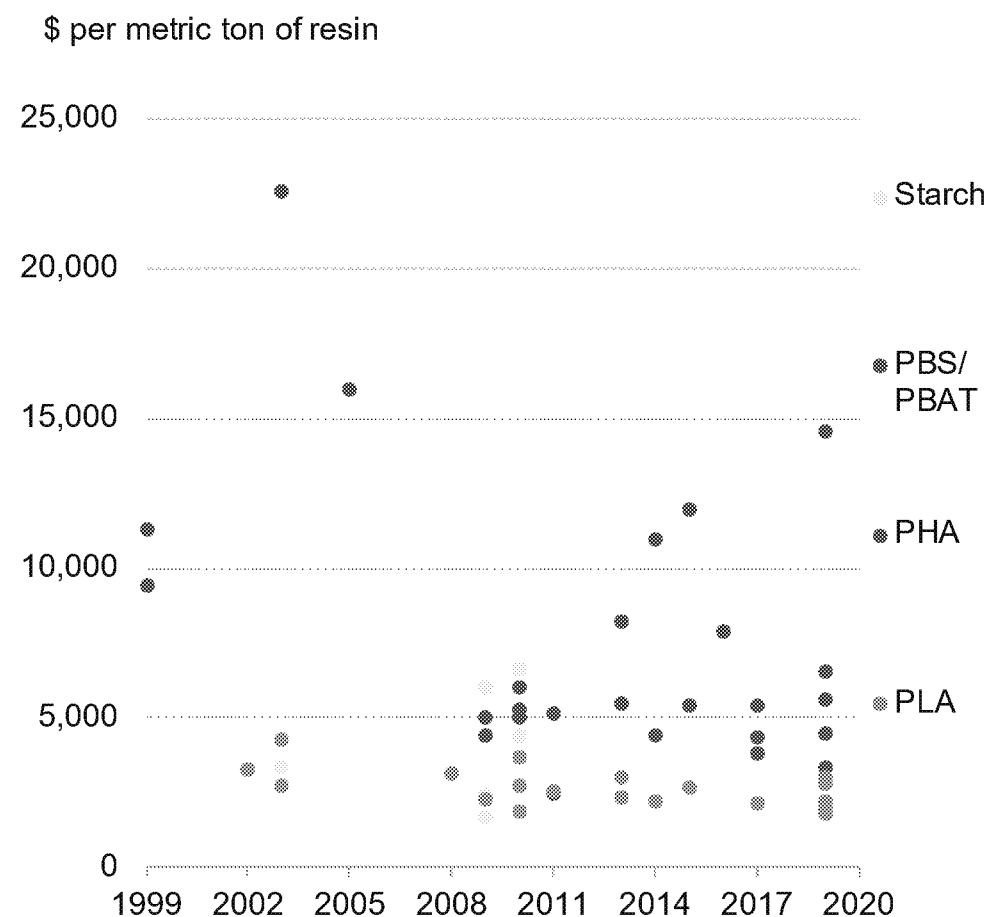
Source: BloombergNEF Note: *bio-PET and *bio-PBS are partly bio-based. †Includes polycaprolactone. Bioplastics covered in this note are commercially available.

Prices are falling, but are still subject to premiums

Prices of drop-in bioplastics



Prices of substitute bioplastics

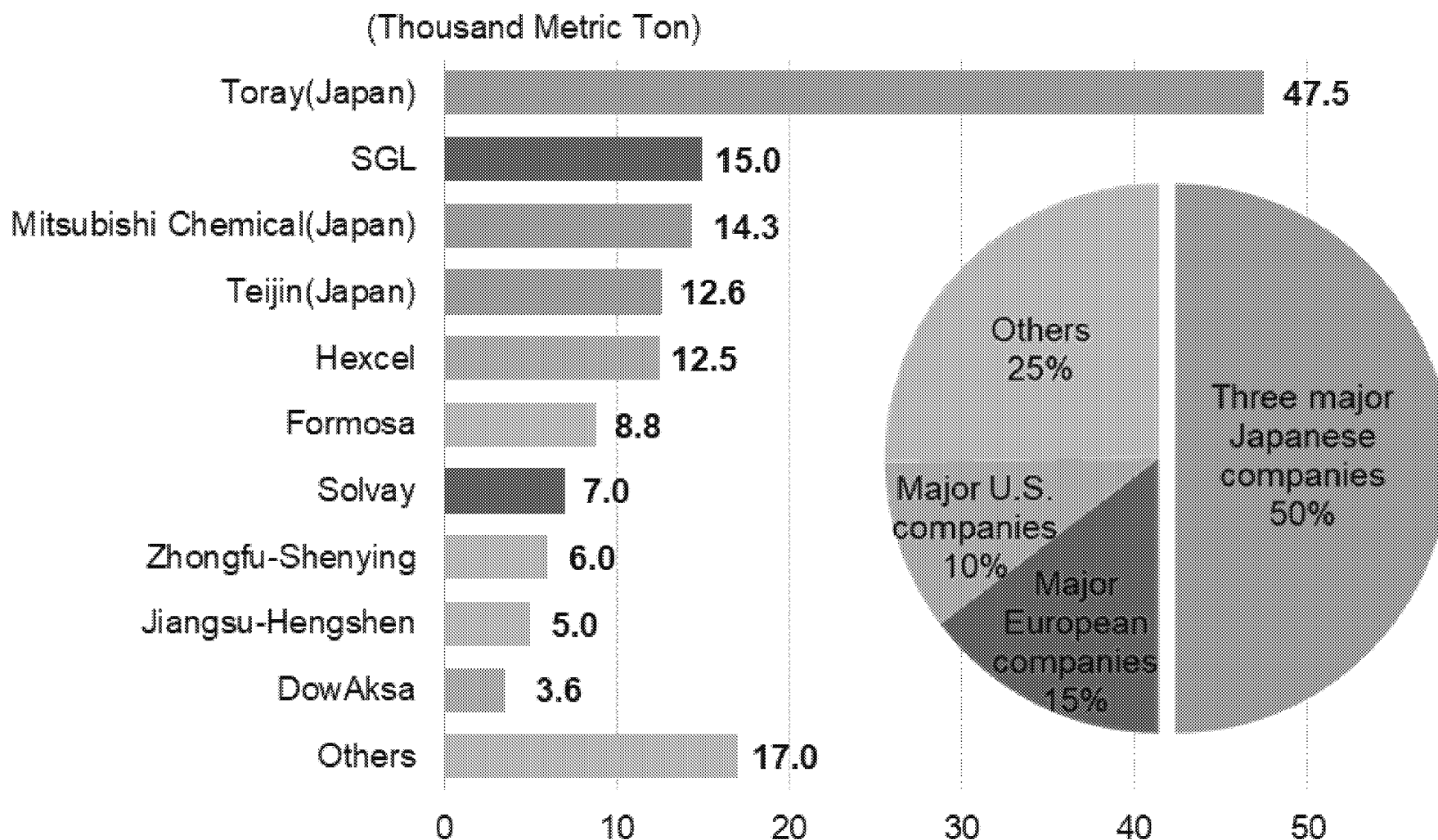


Source: BloombergNEF, company interviews, various academic and market sources Note: multiple prices in a year reflect ranges.

Composites

Supply, demand, pricing

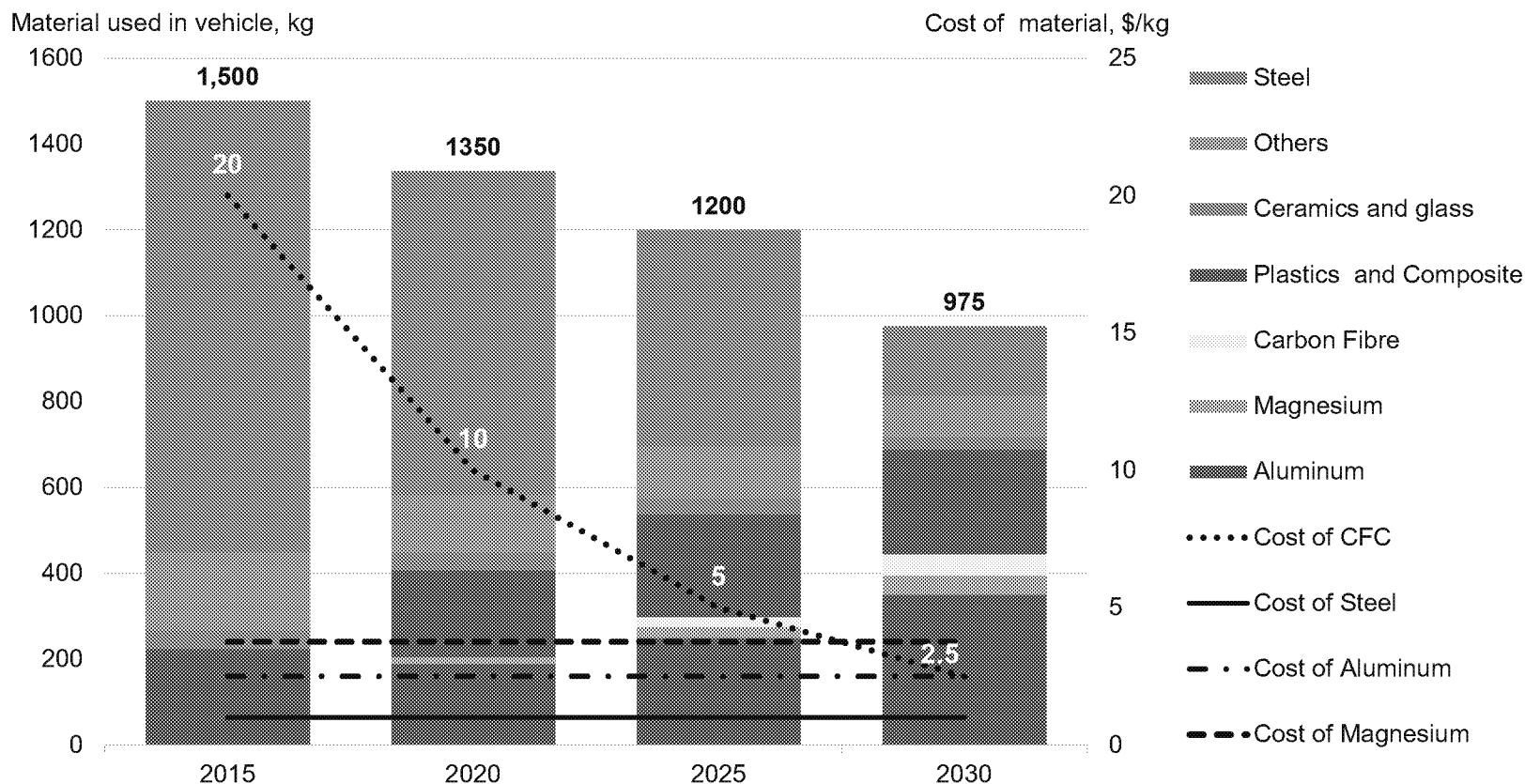
Japanese companies dominate supply



Source: BloombergNEF, AVK

But China has aggressive targets

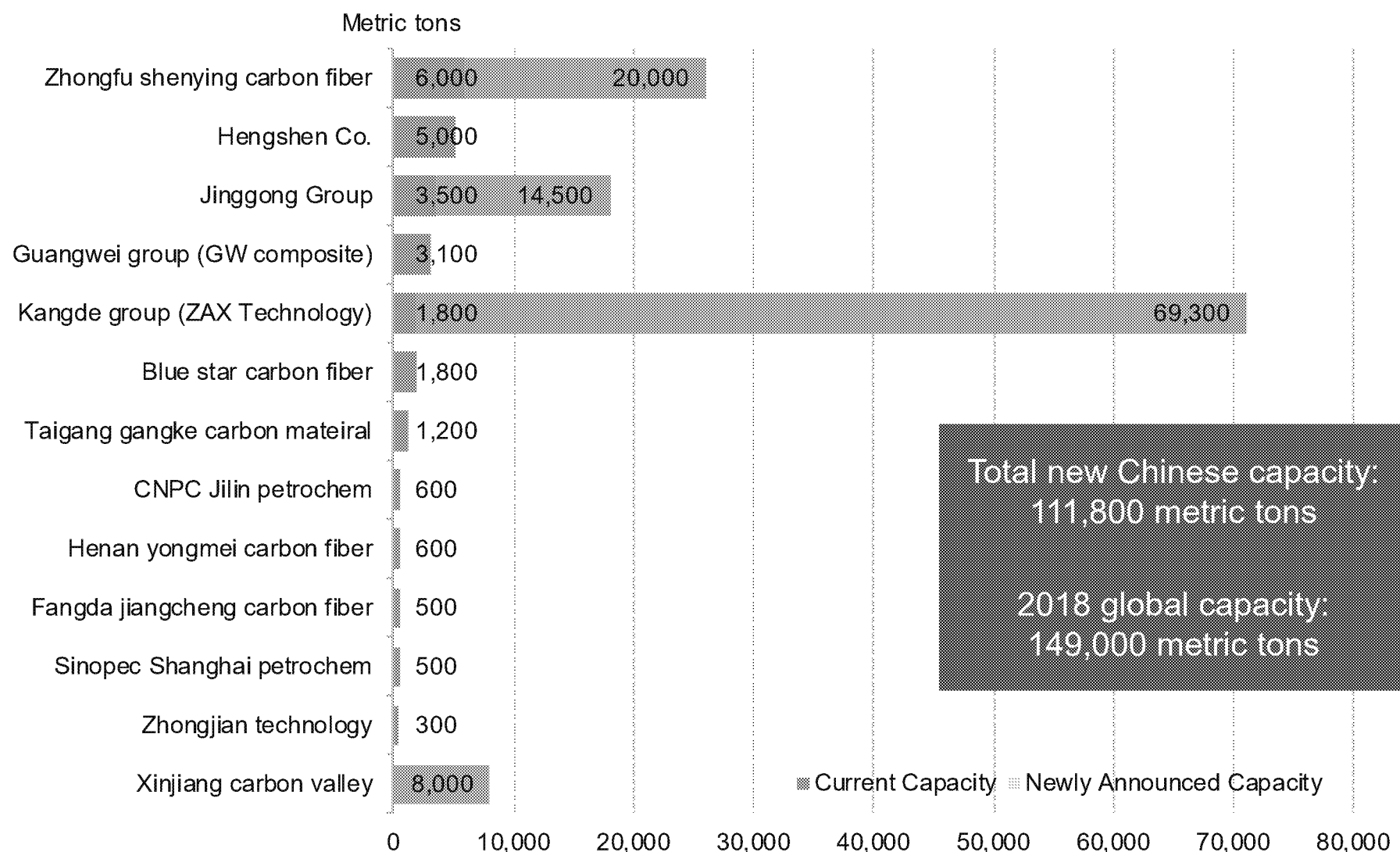
China's Auto Lightweighting Technology Roadmap (suggested targets)



- High strength steel is most widely used
- CHINALCO and Geely are working together on guidance for auto lightweighting.
- Targets: increase aluminum use, CFRP competitive with aluminum by 2030
- Aim to reduce EV weight by 30% by 2030

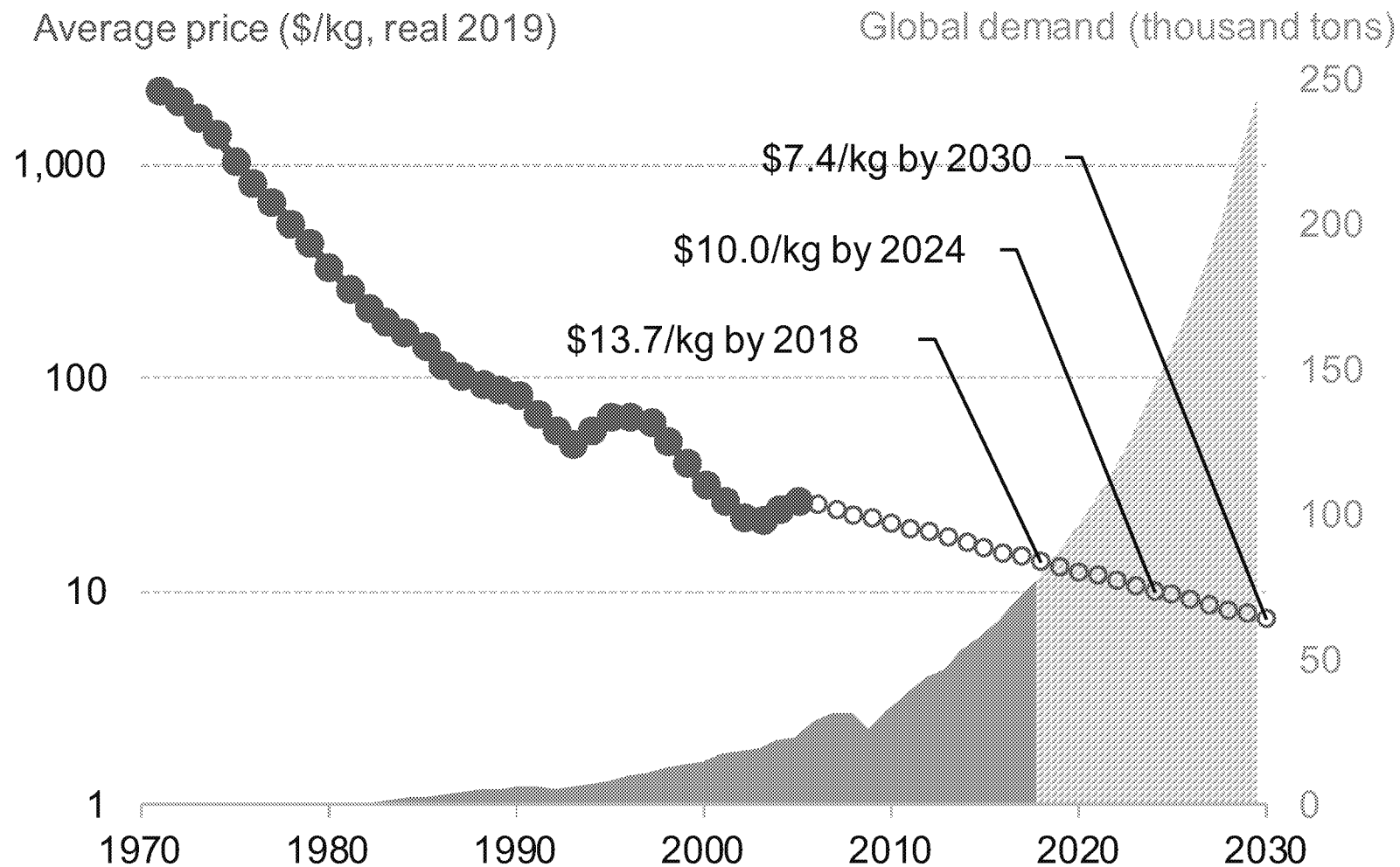
Source: China Industry Research, BloombergNEF, MIIT

And big expansion plans for carbon fiber to match them



Source: BloombergNEF, Company websites, China Petroleum and Chemical Industry Federation(CPCIF)

Carbon fiber will be below \$10/kg by 2024



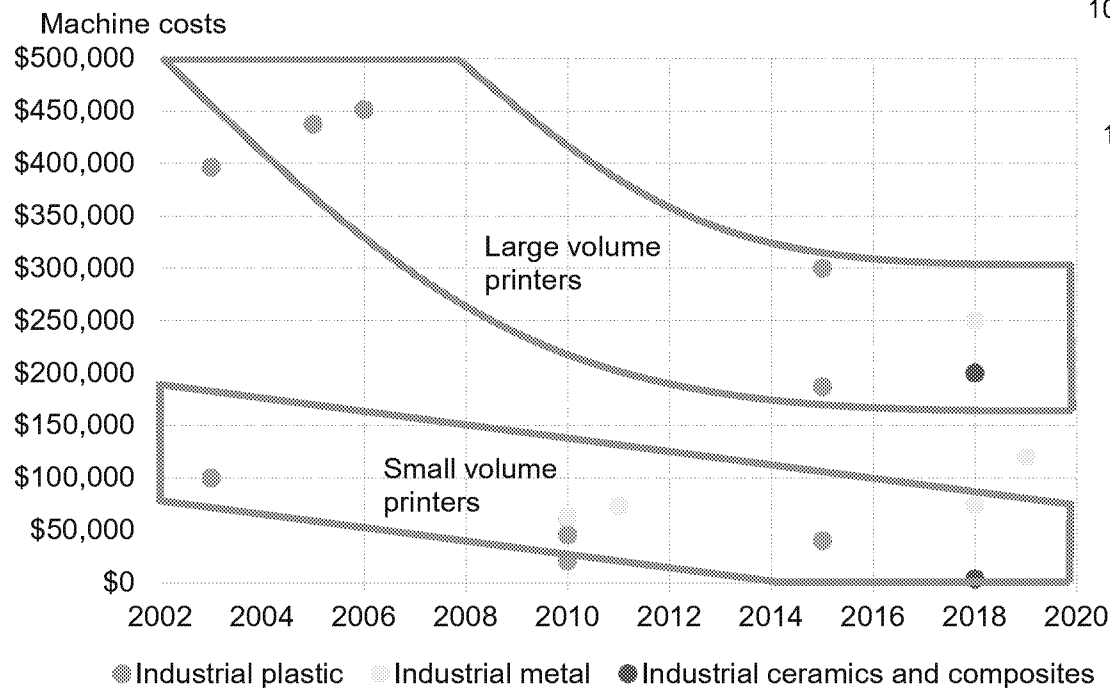
Source: BloombergNEF, Academic papers.

3D Printing

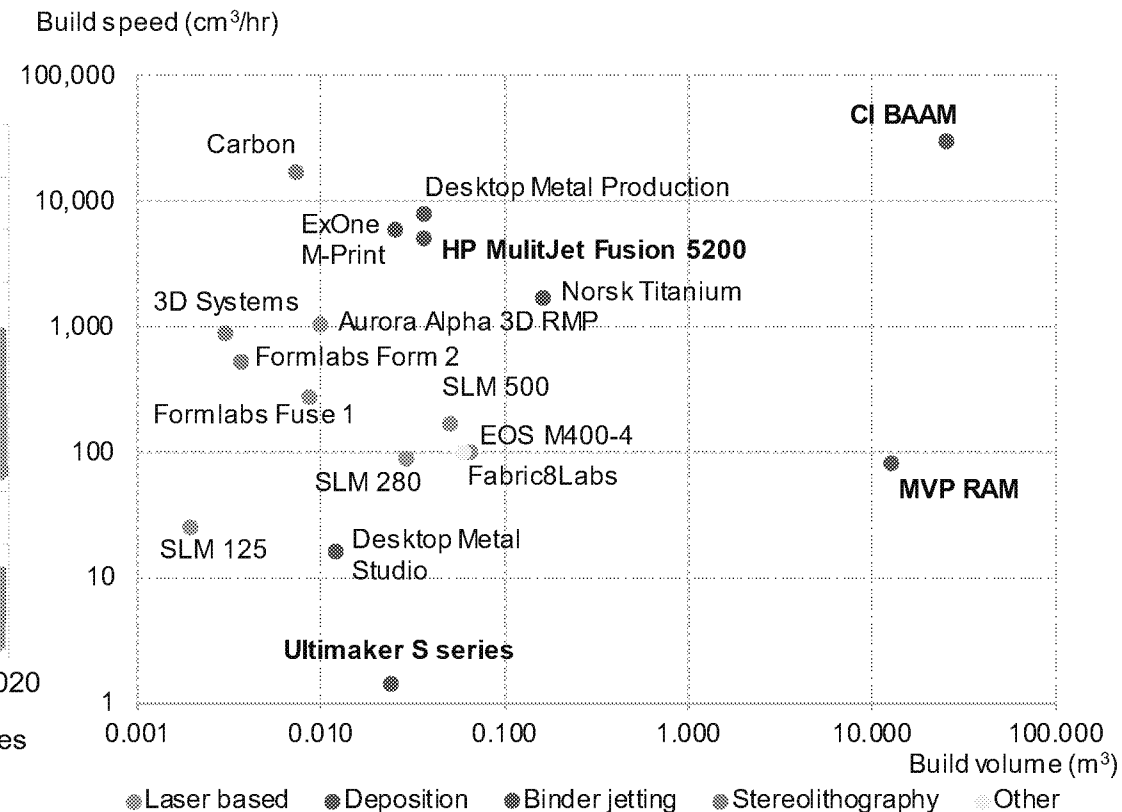
Technology, materials, applications

Technology is improving while costs fall

3D printing machine costs over time

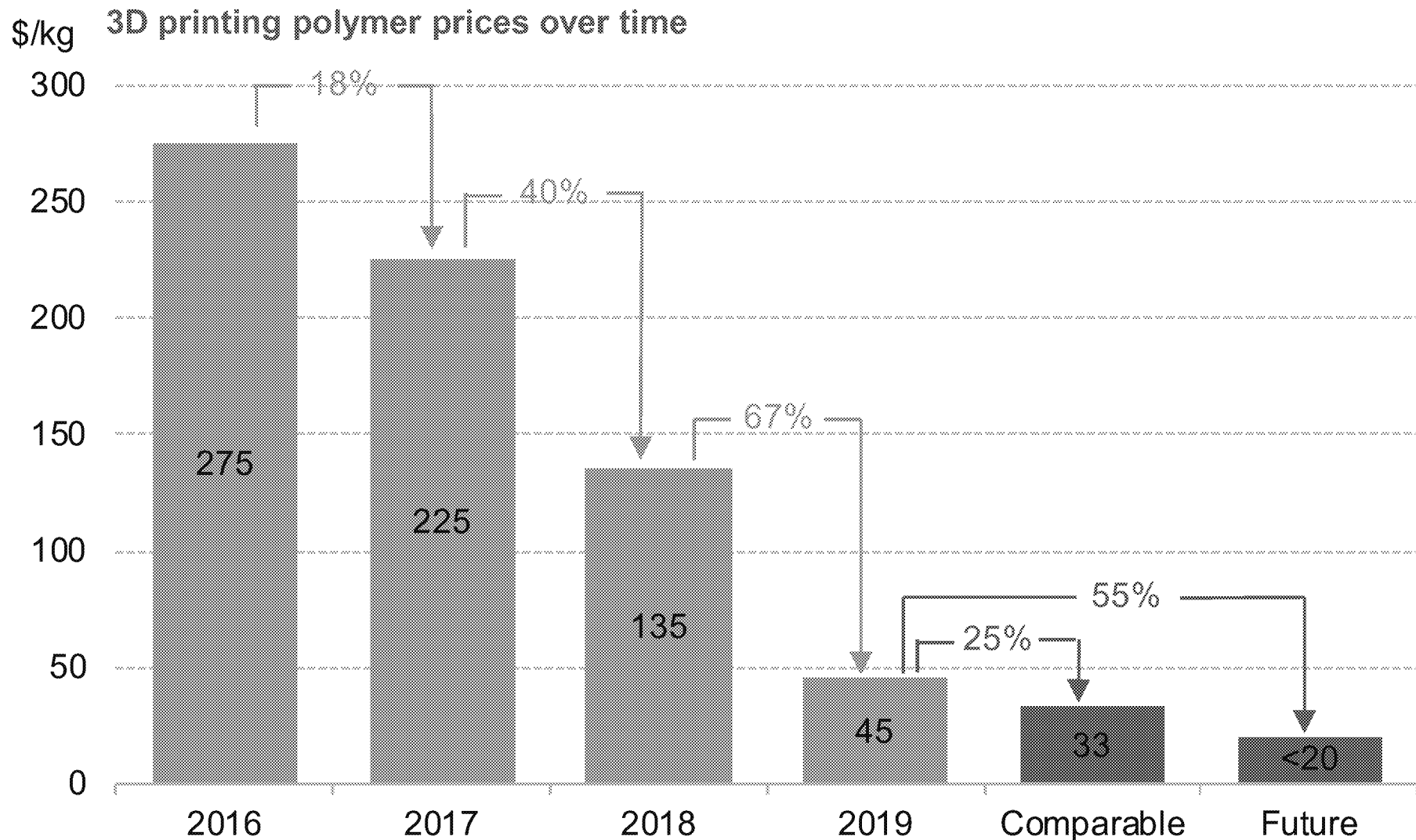


3D printing build size and speed



Source: BloombergNEF, company websites, academic sources. Note: Build speed is shown on a logarithmic axis.

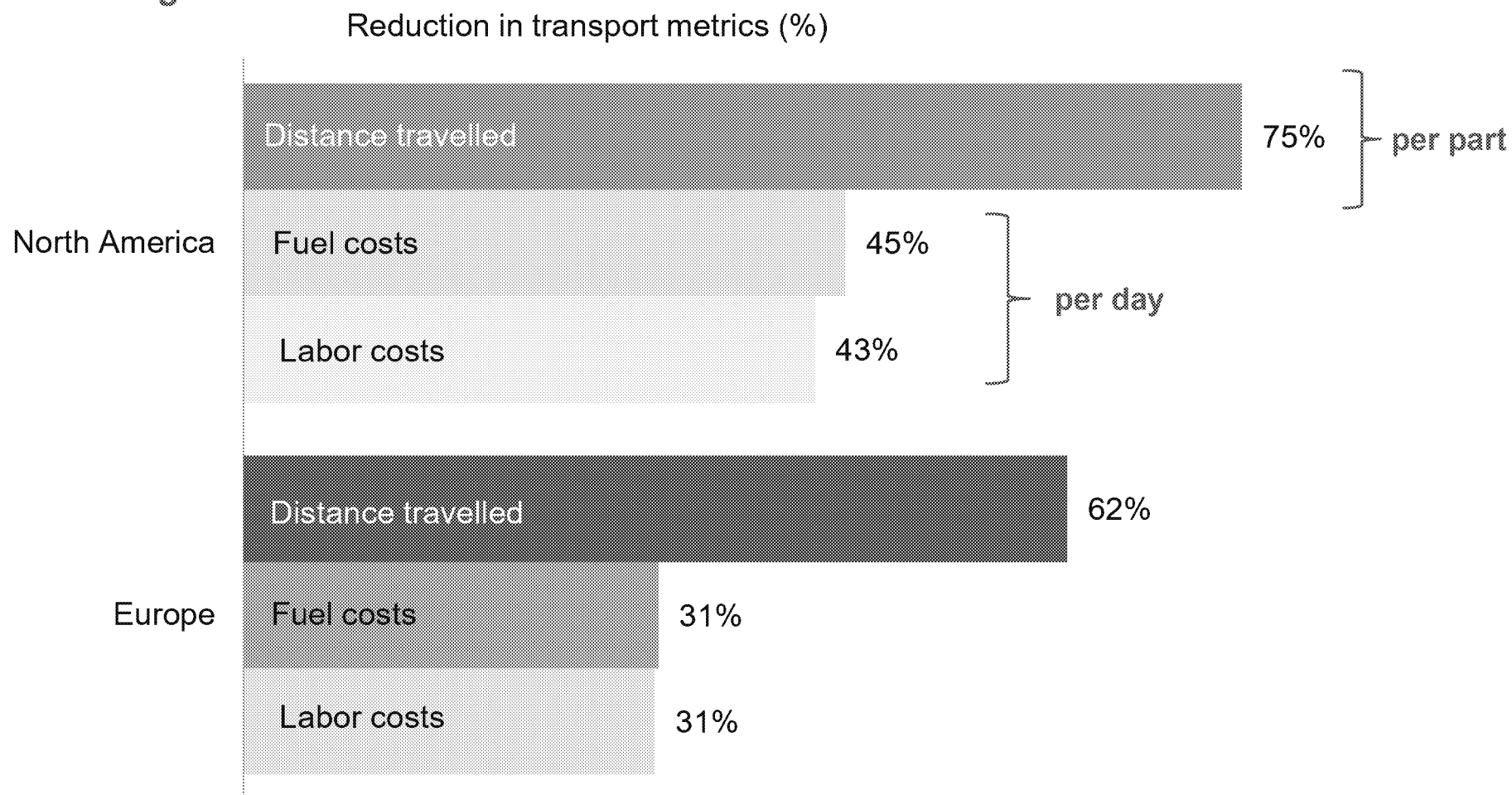
Falling material prices will drive greater adoption



Source: BloombergNEF, Carbon Inc. Note: Purple values are estimations. 'Comparable' is equivalent injection molding materials. 'Future' is expected price at mass-production scale.

Which could cut down on VMT and oil demand

Changes to transportation costs and delivery distances by using 3D printing and just-in-time logistics



Source: BloombergNEF

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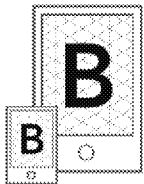
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